

# KENTUCKY TRANSPORTATION CENTER

*College of Engineering*

**VALUE OF RESEARCH: SPR PROJECTS FROM 1995 TO 1999**



UNIVERSITY OF KENTUCKY



## KENTUCKY TRANSPORTATION CENTER

### ***Our Mission***

We provide services to the transportation community through research, technology transfer and education. We create and participate in partnerships to promote safe and effective transportation systems.

### ***We Value...***

Teamwork -- Listening and Communicating, Along with Courtesy and Respect for Others  
Honesty and Ethical Behavior  
Delivering the Highest Quality Products and Services  
Continuous Improvement in All That We Do

*For more information or a complete publication list, contact us at:*

**Kentucky Transportation Center**  
176 Raymond Building  
University of Kentucky  
Lexington, Kentucky 40506-0281

(859) 257-4513  
(859) 257-1815 (FAX)  
1-800-432-0719  
[www.engr.uky.edu/ktc](http://www.engr.uky.edu/ktc)  
[ktc@engr.uky.edu](mailto:ktc@engr.uky.edu)

# **Value of Research: SPR Projects from 1995--1999**

by  
Don Hartman, MSP  
(and others)

Kentucky Transportation Center  
College of Engineering  
University of Kentucky

in cooperation with the Kentucky Transportation Cabinet

and

Federal Highway Administration ◆◆◆ U.S. Department of Transportation

March, 2001

1. Report No. KTC-01-05/MSC1-00-1F	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle  Value of Research: SPR Projects from 1995-1999		5. Report Date March, 2001	
		6. Performing Organization Code	
		8. Performing Organization Report No. KTC-01-05/MSC1-00-1F	
7. Author(s)			
9. Performing Organization Name and Address  Kentucky Transportation Center College of Engineering University of Kentucky		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No.	
		13. Type of Report and Period Covered Final (1995-1999)	
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building		14. Sponsoring Agency Code	
15. Supplementary Notes: Publication of this report was sponsored by the Kentucky Transportation Cabinet with the U.S. Department of Transportation, Federal Highway Administration			
16. Abstract  This report provides summary documentation of the 45 'SPR' research projects funded at the Kentucky Transportation Center (University of Kentucky) from 1995 through 1999. Eleven of these projects were selected for highlighting with up-to-date information regarding results and benefits. They represent a diverse range of research and demonstrate considerable breadth in the implementation of results. Abstracts for all the projects are included in the appendix. A brief discussion of the need/purpose of research, the research process, and the program areas of research at the Kentucky Transportation Center is included.			
17. Key Words  Highways      Value Research      Transportation		18. Distribution Statement  Unlimited, with approval of the Kentucky Transportation Cabinet	
19. Security Classif. (of this report)  Unclassified	20. Security Classif. (of this page)  Unclassified	21. No. of Pages  62	22. Price

# Contents

## Preface

## Applied Research and Its Value..... 7

- What Is Research?
- Who Does Transportation Research?
  - SPR Transportation Research
- Implementation Results and Benefits

## Transportation Research in Kentucky..... 9

- Kentucky Transportation Cabinet and Kentucky Transportation Center
- Research Program and Projects
  - Research Program Areas
    - Construction Management
    - Environmental Analysis
    - Geotechnology
    - Intelligent Transportation Systems
    - Pavements and Materials
    - Policy and Systems Analysis
    - Structures
    - Traffic and Safety
    - Technology Transfer
  - SPR Research Project Listing (by year and program area)

## Research Implementation Examples..... 17

- Summary of Selected Research Projects
- Number One: Development of a Critical Path Method and Training
- Number Two: Protective Coatings for Steel Bridges
- Number Three: Embankment Construction Using Shale
- Number Four: Rock Scour Around Bridge Piers
- Number Five: Intelligent Transportation Systems Strategic Plan
- Number Six: Evaluation of SUPERPAVE Projects
- Number Seven: Pavement Performance with Edge Drains
- Number Eight: Motor Fuel Tax Evasion
- Number Nine: Freight Movement and Intermodal Access
- Number Ten: Seismic Rating and Evaluation
- Number Eleven: Heavy Truck Accidents and Countermeasures

## Appendix..... 39

- Research Project Abstracts by Year of Completion (and program area)

The Wall Street Journal recently reported that a 'big name' Stanford University economist believes that "the U.S. isn't turning out enough scientists and engineers to make the discoveries that will pay off in 50 years." Concern has grown nationally about a shortage of technical and scientific graduates as well as the lessening of expenditures for research and development. A recent publication, "The New Challenge to America's Prosperity," contends that we stand to lose competitiveness and prosperity and that the most critical factors include: the number of those dedicated to R&D and the amount of investment directed to R&D. Transportation research plays a vital part in assuring the future effectiveness and efficiency of our transportation system which itself is critical to the future economic development of the Commonwealth.

### Acknowledgements

The work of dedicated project leaders and their research teams has made this report possible. Those eleven research projects highlighted in this report required the project leader to further review results and consider the accrued benefits since completing the projects. We appreciate the extra time spent by them for the purpose of this report. A special thanks goes to Pat Riggs for her work on the appendix and to Chas J. Hartman for his editorial suggestions to the final draft.

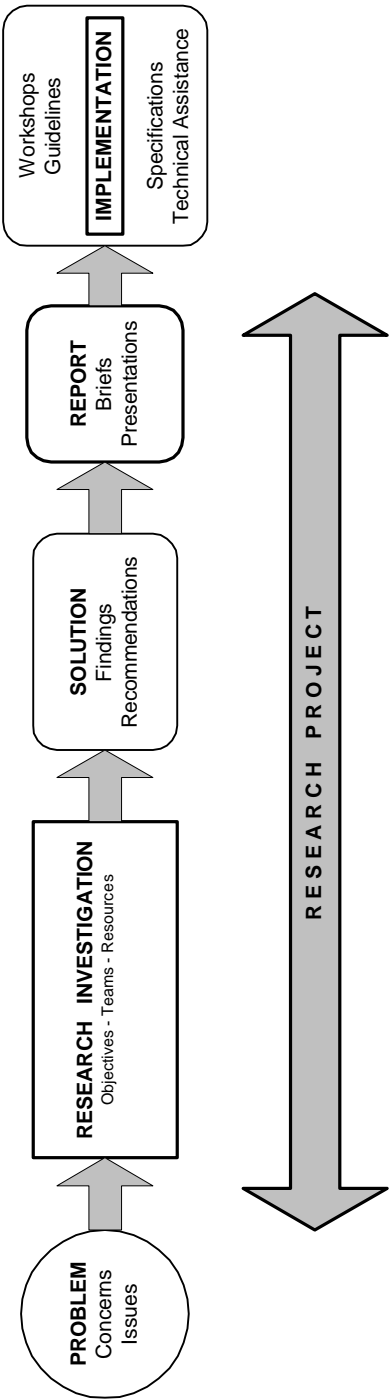
## Preface

Why do we have to be reminded occasionally about the usefulness or value of research? Could it be because we are just too impatient and want to see bottom line results now or at least by the end of a quarter? Yet, we seem to endlessly call for things to be improved and for stretching the dollar to cover more. Figuring out just how to do this is the purpose of 'applied research.' The challenge is in not taking too long or costing too much to achieve that purpose.

This brief report covers the 'SPR' highway transportation research in Kentucky and provides a sampling of the results of research completed from 1995-1999 by the Kentucky Transportation Center. The Kentucky Transportation Cabinet and the Federal Highway Administration funded this research project work. An abstract of each completed research project is included in the Appendix. Areas of research during this period include: (1) construction management; (2) environment analysis; (3) geotechnology; (4) intelligent transportation systems; (5) pavements and materials; (6) policy and systems analysis; (7) structures; and (8) traffic and safety. The specific research work examples, selected for highlighting, demonstrate how fact-finding and problem-oriented research finds solutions that can be implemented. The output of the highlighted research is discussed in terms of its useful results and benefits. The projects chosen for case study present a variety of applied research outputs contributing to improvements in the planning, design, construction, maintenance, and operation of Kentucky's highway transportation system.

The Center has in the past offered its research capability to other agencies, levels of government, universities, and the private sector. Some of those include: the Kentucky State Police; the Lexington Bluegrass Airport; the US Navy; Northwestern University; Toyota; and TRW. The Kentucky Transportation Center at the University of Kentucky enjoys strong support within Kentucky and has begun to establish a national recognition for its research capability.

# Step-by-Step Research Process





# Applied Research and Its Value

## What Is Research?

It can best be defined by describing how it works. Applied research works in simple steps:

- Identify the **problem**;
- Conduct an **investigation**;
- Formulate a **solution**;
- Make a **report**; and
- Provide **implementation** tools.

See the diagram on the facing page that shows the 'ideal' step-by-step process and the typical outputs of each step from a listing of specific concerns or issues (at the beginning) to the provision of workshops or technical assistance (at the end). What we have defined here is applied research, not that 'basic research' conducted to discover the nature of a thing, for the sake of increasing the knowledge base. It should be noted that not all applied research projects go through the complete sequence as listed above and shown in the diagram. Some projects pick-up where another left off or combine the information of several others to produce something useful. So applied research is not very pristine in intent, but it is more practical in terms of providing readily useful results. In order to be useful, applied research is limited in two ways: time and funding. However, the concept of a research project being on time and under budget is foreign to many university-based researchers. Improving the management of applied research is a major challenge.

*Research is always considered incomplete by the researcher, but its imperfect results meet our continuing need for improvement.*

## Who Does Transportation Research?

Transportation research, like many other kinds of research, is carried out in three venues: government, universities, and industry. The generally acknowledged promise of research to increase knowledge and/or solve problems ensures governmental interest, especially in transportation research for its contribution to economic development and national security. On a more local level, government concerns focus on congestion, safety, and environmental harmony. Traditionally, universities were more oriented toward basic research and industry toward applied research. However, today the government operates research and development

laboratories, universities conduct both basic and applied research, and industry aggressively pursues both invention and innovation recognizing the need for a full range of research to stay economically competitive.

Why Do 'SPR' Research? SPR stands for State Planning and Research a federal-state program that supports highway transportation planning and research. The annual funding a state receives that is designated for the research portion is  $\frac{1}{4}$  of the total SPR funds. A state receives 2 percent of the total amount of several major federally funded construction and maintenance programs for the purpose of planning and research. These federal SPR grant funds must be matched with state funds currently at an 80/20 ratio. Developing and operating the surface roadway system in the US is a major responsibility of government and research on materials, methods, and systems is an integral part of that responsibility. It is the promise of research -- to provide knowledge and solutions that result in saving money, saving time, and with transportation saving lives -- that sustains governmental interest and the continuing investment.

## **Implementation: Results and Benefits**

When we think about research performance it may be useful to consider the three-part approach that is often used in evaluation:

- 1) Where the research objectives achieved?
- 2) Can we attribute benefits to the solution?
- 3) Will it work in the real world?

The first level requires that we clearly know the research objectives so that we can assess their degree of accomplishment. Yet even if the stated objectives are accomplished one expects there to be demonstrable if not quantifiable results. Sometimes benefits can be shown very clearly on paper, but they just do not materialize or accumulate in the long run. And sometimes it just takes a long time for research recommendations to be implemented broadly enough and long enough to show significant results. Among the projects highlighted in this report, results/benefits include: a scheduling method that promises a potential time savings during construction; a unique asphalt mix that extends pavement life for a real dollar savings; and truck accident countermeasures that can actually save human lives (and reduce property damage).

# **Transportation Research in Kentucky**

## **Kentucky Transportation Cabinet and Kentucky Transportation Center**

In 1941 the Kentucky Department of Highways located its Division of Research adjacent to the University of Kentucky campus in Lexington. The Kentucky Transportation Cabinet transferred the Division of Research (including employees) and its facilities to the University of Kentucky in 1981. This formed the Kentucky Transportation Research Program in the College of Engineering. It was combined in 1988 with the technology transfer program (a federally funded program to assist local governments) to form the current Kentucky Transportation Center at the University of Kentucky.

## **Research Program and Projects**

Research Program Areas. This section of the report provides a brief overview of the research program areas of the Center and a five-year listing of the completed SPR projects.

## **Construction Management**

The Center reflects a growing interest in the processes and procedures of more efficient and effective roadway construction and project management. Issues in construction range from preparing improved cost estimates for planned projects to insuring the quality of completed highway projects. The Center has available expertise in 'QC' (Quality Construction) approaches, performance evaluation, and construction project scheduling using computer-based systems. A special area of research emphasis examines the advantages and disadvantages of innovative practices such as nighttime construction and the procedures necessary for successful implementation. The Center also tracks and evaluates innovative contracting methods such as those used in the reconstruction project for Paris Pike (US 68 between Lexington and Paris, Ky.), one of the most unique construction projects ever begun in Kentucky.

## **Environmental Analysis**

Environmental concerns have become a major factor that impacts all phases of transportation project development and highway system maintenance. It will become increasingly important for transportation agencies to address these concerns in a timely manner. Focused research, advanced technology and new materials applications hold promise for the future. The Center has expertise in developing new environmentally compliant coating systems for steel bridges, conducting nondestructive testing methods, developing environmental support software, preparing ground water protection plans, and facilitating regional collaboration among states' highway bridge maintenance units. The collaboration effort is ongoing and involves seven states and Northwestern University.

## **Geotechnology**

Geotechnical research focuses on finding better ways of defining the shear strength of soils and rocks, models that accurately predict behaviors and stabilities, improving compaction methods and equipment, and the use of synthetic and lightweight materials to reduce stress on soft foundations. The Center has experienced geotechnical and aggregate testing personnel who work in the field and the laboratory. Specific expertise includes settlement analysis, bearing capacity analysis, slope stability analysis, computer simulation of slope rock falls and rock fall potential, and the chemical and mechanical stabilization of pavement subgrades.

## **Intelligent Transportation Systems**

Revolutionary changes are underway in surface transportation with advanced technology applications relying on sensors, computers, and communication. Traveler information systems will provide both urban and rural travelers with unprecedented access to information. Traffic management systems will maximize the effective use of existing facilities and minimize the impact of incidents. Commercial vehicle regulation and enforcement will be accomplished seamlessly and effectively with minimal disruption to safe and legal carrier operations. The Center has developed expertise in the planning, designing, demonstrating, testing and evaluating Intelligent Transportation Systems applications. A nationally significant amount of research and development work is continuing to be accomplished in the area of commercial vehicle operations. Some of this work has been done in conjunction with Johns Hopkins University and TRW.

## **Pavements and Materials**

The problem of constructing roadway pavement and its long-term performance is the focus of this area. A major emphasis is in reducing water infiltration into the pavement and removing infiltrated water from the pavement. The Center has expertise in pavement design, construction, and management. Research topics include: paving and construction materials, pavement drainage systems, traffic loading impact and structural testing. Special expertise exists in pavement life-cycle cost analyses and the development/delivery of workshops for pavement design. A significant amount of work has been done evaluating the performance SUPERPAVE hot-mix asphalt pavement and work is underway to evaluate the loading and environmental effect on concrete pavements.

## **Policy and Systems Analysis**

This area of research is quite diverse and assignments are a direct result of demand for technology solutions—examining the cutting edge and its significance for the future. Work includes examining existing systems and designing changes for improvement that include uses of appropriate technology. Much of the work is planning-for-the-future oriented that includes assessing and developing new tools for transportation facility planning such as GIS (Geographic Information Systems) for example. Both interdisciplinary problem solving and participatory design is encouraged. The Center has developed a high level of expertise in using various technologies of citizen participation including: group facilitation, electronic polling, and computer-aided visualization.

## **Structures**

Structures research at the Center focuses primarily on highway bridges and on the use of fiber reinforced composite applications for bridge decks and girders. In the future, advanced fiber reinforced composites will be used extensively for strengthening and retrofitting existing structures. Other areas of investigation include seismic (earthquake) evaluation of bridges, barge and truck impact on bridges, and the laboratory testing of structural components. A high level of expertise has been developed in assessing earthquake potential, susceptibility of existing structures, and options for retrofitting these structures. The Center was instrumental in the design and construction of the Clear Creek Bridge, the longest composite girder bridge in the world.

## **Traffic and Safety**

Concerns of traffic and safety on our roadways are likely to become more acute in the future. The Center has a long and highly recognized history of work in this area. The research has ranged from determining the equitable allocation of highway costs to user groups to the analysis of incident management procedures. Annually the Center prepares a 'traffic accident facts' report for the Kentucky State Police along with special analyses relating to topics such as the driver license system and safety belt use. The staff has developed expertise in traffic forecasting, traffic control devices and system management, and roadway delineation devices and materials. There is a close working relationship with the Intelligent Transportation Systems and Technology Transfer groups. Workshops ranging from tort liability and risk to safety features for local roads and streets have been developed.

## **Technology Transfer**

While technology transfer is not a 'research area' it has the potential to facilitate all of the Center's research work by making results known. The capability of the Center to transfer and exchange technology has received national recognition. Programs of training have been developed that cover basic operation, supervision and management, and highly skilled operations relating to highway traffic and maintenance at state, district, and local levels. The Center maintains a library with an extensive video collection for use by state and local roadway personnel. The wide range of resource materials that are made available include various training manuals and guides. The Center publishes a quarterly newsletter (The Link) and makes available the Kentucky Transportation Directory annually.

SPR Research project Listing. The following is a five-year listing of the Center's completed SPR projects. They are grouped by year and research area.

## **1999**

### ***Environmental Analysis***

- |           |  |
|-----------|--|
| KTC-99-2  | "Development of an Information Management System for Assisting Kentucky Transportation Cabinet Personnel Concerning Environmental Issues," Bobby Meade |
| KTC-99-52 | "Assessment and Modeling of Stream Mitigation Procedures," Bobby Meade   |

### ***Geotechnology***

- |           |  |
|-----------|--|
| KTC-99-57 | "Correlation of Rock Quality Designation and Rock Scour Around Bridge Piers and Abutments Founded on Rock," Tommy C. Hopkins |
|-----------|--|

### ***Pavements and Materials***

- |           |   |
|-----------|---|
| KTC-99-1  | "Development of ESAL Forecasting Procedures for Superpave Pavement Design," Brad Rister |
| KTC-99-53 | "Evaluation of SUPERPAVE in Kentucky," John Fleckenstein                                |
| KTC-99-59 | "Economic Impact of Heavy Loads On the Highway Infrastructure," David Allen             |

### ***Policy and Systems Analysis***

- |           |   |
|-----------|---|
| KTC-99-65 | "Freight Commodity and Intermodal Access in Kentucky - Freight Movement and Intermodal Access in Kentucky," Lisa Aultman-Hall |
| KTC-99-50 | "Kentucky's Road Fund Tax Structure," Dr. Merl Hackbart   |

### ***Structures***

- |           |  |
|-----------|--|
| KTC-99-16 | "Seismic Evaluation of the US 41 NORTHBOUND Bridge over the Ohio River at Henderson, Ky," Issam E. Harik |
| KTC-99-17 | "Seismic Evaluation of the US 41 SOUTHBOUND Bridge over the Ohio River at Henderson, Ky," Issam E. Harik |
| KTC-99-22 | "Laboratory Testing and Analysis of Joints for Rigid Pavements," Issam E. Harik                          |

### ***Traffic and Safety***

- KTC-99-20 "Heavy Truck Involvement in Traffic Accidents," Jerry G. Pigman
- KTC-99-23 "Evaluation of Kentucky's Driver License Renewal Process," Nick Stamatiadis
- KTC-99-48 Final Summary Report on "Truck Route Access Evaluation," Freight Movement & Intermodal Access in Kentucky, Lisa Aultman-Hall

### ***Technology Transfer***

- KTC-99-3 "Employee Satisfaction Survey," Bennett Tepper and Patsy Anderson

## **□□□ 1998 □□□**

### ***Construction Management***

- KTC-98-18 "Cost Estimating and Forecasting for Highway Work in Kentucky," James D. Stevens

### ***Geotechnology***

- KTC-98-2 "Embankment Construction Using Shale," Tommy C. Hopkins

### ***Pavements and Materials***

- KTC-98-21 "Analysis of Vehicle Classification Data, Including Monthly and Seasonal ADT Factors, Hourly Distribution Factors, and Lane Distribution Factors," David L. Allen

### ***Structures***

- KTC-98-1 "Seismic Isolation of a Highly Skewed Prestressed Concrete Girder Bridge," Brad Robson
- KTC-98-20 "Seismic Evaluation of the Ohio River Bridge on US51 at Wickliffe, Kentucky," I. E. Harik

### ***Traffic and Safety***

- KTC-98-3 "1998 Highway Cost Allocation Update Technical Report," Samantha S. Jones
- KTC-98-5 "Investigation and Analysis of Heavy Truck Accidents," Jerry G. Pigman
- KTC-98-9 "Intelligent Transportation Systems Strategic Plan," Jerry G. Pigman

- KTC-98-11    "Evaluation of Kentucky's Driver License Point System and Retesting Criteria," Kenneth R. Agent
- KTC-98-14    "A Methodology for Evaluating Large Truck Access to Intermodal and Other Facilities," Lisa Altman-Hall

### ***Technology Transfer***

- KTC-98-19    "Annual Assessment of Customer Needs and Satisfaction," Patsy Anderson

## **□□□ 1997 □□□**

### ***Construction Management***

- KTC-97-22    "Development of A Critical Path Method Specification and a Training Program for Use of CPM for KyTC," Donn E. Hancher

### ***Pavements and Materials***

- KTC-97-5    "Performance and Cost Effectiveness of Pavement Edge Drains," L. John Fleckenstein
- KTC-97-8    "Subsurface Drainage of Highway Pavements," David Q. Hunsucker

### ***Policy and Systems Analysis***

- KTC-97-14    "Legislation Review and Recommendations to Reduce Evasion of Kentucky Road Fund Revenues," Dwight Denison

### ***Structures***

- KTC-97-1    "Dynamic Site Periods for Jackson Purchase Region of Western Kentucky," R. Street

### ***Traffic and Safety***

- KTC-97-6    "Evaluation of Speed Limits in Kentucky," Jerry G. Pigman

## **□□□ 1996 □□□**

### ***Construction Management***

- KTC-96-14    "Cost Estimating and Forecasting for Highway Work in Kentucky," James D. Stevens



### ***Environmental Analysis***

- KTC-96-7 "Environmentally Safe Protective Coatings for Steel Structures - New Construction and Maintenance Painting," Theodore Hopwood, II

### ***Pavements and Materials***

- KTC-96-8 "A Proposed Method of Calibration and Correlation of Weigh-in-Motion Systems," David L. Allen
- KTC-96-10 "Evaluation of Superior Performing Portland Cement Concrete Pavements in Kentucky," Jerry G. Rose

### ***Policy and Systems Analysis***

- KTC-96-16 "The Motor Fuel Tax Evasion Issue in Kentucky," Dwight Denison

## **□□□ 1995 □□□**

### ***Pavement and Materials***

- KTC-95-1 "A User's Guide for By-Product and Discarded Material Utilization in Highway Construction and Maintenance," Kamyar Mahboub
- KTC-95-6 "Development of An Alternate Methodology for Identifying Heavy/Coal Trucks and Calculating ESAL's/Axle and Axles/Truck," Jack A. Harrison
- KTC-95-13 "A Life-Cycle Cost Analysis Program for Kentucky Pavements," Jack A. Harrison
- KTC-95-18 "Pavement Distress at Intersections," David Q. Hunsucker

### ***Policy and Systems Analysis***

- KTC-95-3 "Toward Determining/Optimal Transportation Department Resource Requirements: An Examination of State Privatization Trends Among Selected States," Merl Hackbart

### ***Traffic and Safety***

- KTC-95-5 "Development of A Safety Management System," K. R. Agent
- KTC-95-7 "Equivalent Single Axleload Computer Program Enhancements," Jerry G. Pigman,
- KTC-95-25 "Impacts of Extended Weight Coal Haul Road System," Jerry G. Pigman



## **Research Implementation Examples**

Research Topic		Results	Benefits	Rpt. #
1	Critical Path Construction Scheduling	Delivered workshop and 'specification' for construction project scheduling tool.	Central/district staff understand use of tool to track projects and reduce delays.	KTC-97-22
2	Protective Coatings for Steel Bridges	Developed a new coating system that offers superior performance on steel bridges.	\$26 million saved on painting of 100 Kentucky bridges. (based on national av.)	KTC-96-7
3	Embankment Construction Using Shale	Prepared compaction specification to avoid embankment settlement and failure.	Special specification for shale compaction is saving millions of dollars annually.	KTC-98-2
4	Rock Scour Around Bridge Piers	Determined from collected data that rock scour is not a significant problem.	Eliminated the need for \$30 million analysis as suggested by FHWA.	KTC-99-57
5	Intelligent Transportation Systems Strategic Plan	Developed a set of goals/recommendations with the input of 100 stakeholders.	Planned deployment assures development that meets needs more efficiently.	KTC-98-9 KTC-00-5
6	Evaluation of Asphalt SUPERPAVE Projects	Confirmed SUPERPAVE mixtures perform better without a substantial cost.	Adopting SUPERPAVE will extend pavement life 3-4 years.	KTC-99-53
7	Pavement Performance with Edge Drains	Determined significant impact of drains on long-term performance of roadways.	Using recommended drain design, a cost savings of \$240,000/mile is expected.	KTC-97-5
8	Motor Fuel Tax Evasion Reduction	Recommended steps to reduce evasion and increase Kentucky Road Fund revenues.	Changes in procedures and the special revenue analysis unit will produce results.	KTC-97-14 KTC-97-16
9	Freight Movement and Intermodal Access	Identified route/points for improvement and demonstrated use of forecasting data.	Identifies priority projects to reduce truck traffic congestion and improve safety.	KTC-99-48 KTC-99-65
10	Seismic Rating and Evaluation of Highway Structures (W. Ky.)	Conducted stability assessment of bridge approaches and retaining structures.	Retrofitting major bridges for earthquake will potentially save \$10 million/bridge.	KTC-97-1 KTC-98-1/20 KTC-99-16/17
11	Heavy Truck Accidents and Countermeasures	Identified critical truck crash rate sections and suggested countermeasures.	Selected countermeasures—injury crashes avoided save \$15-39,000 each.	KTC-98-5 KTC-99-20

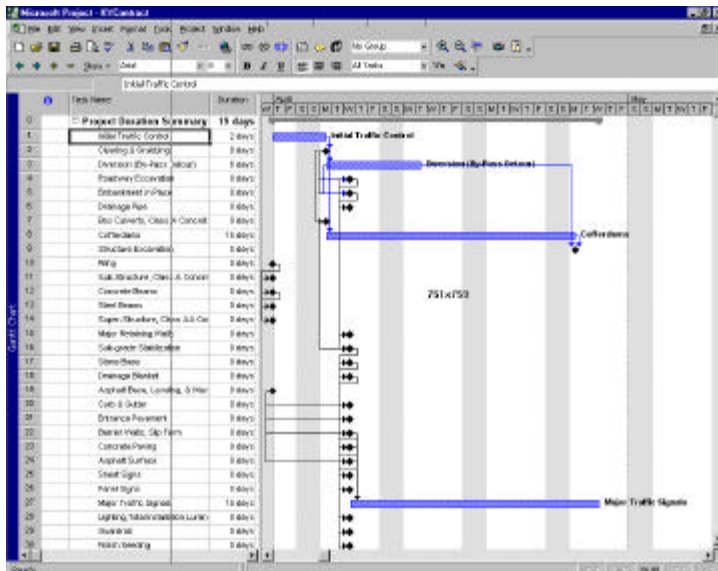
## Summary Table of Eleven Selected Research Projects

### Notes:

1. A brief description of each of these projects and their results/benefits can be found in this report.
2. Complete documentation of each research project can be obtained by requesting the published report by title or reference number (KTC-00-00)

## Research Implementation Examples

The following case study example group was chosen from the 45 SPR highway research projects completed during 1995 -1999. They were selected to demonstrate the diversity of the research program and the range of uses for the results. A summary table of the eleven selected SPR research projects is presented on the facing page. The case study projects are each highlighted in this section of the report with information regarding resources invested, objectives and results, and implementation and benefits. Abstracts for all SPR research projects completed during the period can be found in the Appendix.



**Number One: Development of a Critical Path Method and Training**  
[Ref. #'s SPR-96-167 and KTC-97-22]

### Resources

Project Leader – Donn Hancher, PhD, PE  
Study Advisory Committee Chair – John Sacksteder  
Investment Amount – \$115,533  
Duration – 1996--1997

## Objectives and Results

The project objectives were as follows:

- Evaluate the Transportation Cabinet's needs for project scheduling and current practices (including other states)
- Prepare a sample specification for an appropriate construction project scheduling method
- Develop and conduct a training program for agency personnel and contractors using the recommended method

Current practices of the agency were examined and an extensive survey of the practices of other DOT's was completed. A guideline was developed to implement a 'Critical Path Method' of construction project scheduling. A workshop was developed and delivered to agency personnel that included the developed guideline materials. Its purpose was to provide an understanding of the basic fundamentals and essentials of project scheduling as well as a beginning competence in the use of computer-aided scheduling as a construction management tool. Primavera's *Suretrak* scheduling software was demonstrated as an example of available tools. Four workshop/seminars were conducted to accommodate Central and District Office personnel of the agency: two were held at the UK main campus, one at Elizabethtown Community College, and one at Prestonsburg community College. After the training a follow-up survey was conducted and results were taken into account for the development of the agency's 'specification' of a scheduling technique.

## Implementation and Benefits

Project scheduling workshops were attended by 76 of the agency's personnel from central and district offices. This project provides the benefit of more comprehensive and consistent use of a computer-aided scheduling tool. It provides agency personnel with a systematic method to track the progress of projects and quickly alert them to potential delays. It is also expected to reduce the potential for schedule-related claims against the agency.



**Number Two: Protective Coatings for Steel Bridges**  
[Ref. #'s SPR-92-140 and KTC-96-7]

Resources

Project Leader – Theodore Hopwood II, PE  
Study Advisory Committee Chair: Robert Banta  
Investment Amount – \$258,987  
Duration – 1992-1996

Objectives and Results

The following were the major objectives of the research work:

- Identify new or advanced structural steel coatings that meet environmental regulations now and in the foreseeable future
- Develop laboratory and field testing methods to analyze both coatings and application procedures
- Collect data and monitor results of laboratory and field testing program
- Prepare specifications (including methods) to improve the economics of coating and future maintenance of steel bridges

As a result of the research findings, new coating systems were developed that offer superior performance and are expected to meet EPA regulations through 2005. KYTC specifications derived from this study are also being used by other states' highway agencies. Kentucky is considered a leader in low-cost bridge maintenance painting. The multi-disciplinary paint team that was established to

guide this research has continued its existence beyond the study period to assure continuous improvement of coating performance and environmental compliance.

### Implementation and Benefits

Kentucky has implemented the majority of findings and recommendations that grew out of the research work and the KYTC experimental over-coating program is recognized nationally as being innovative and successful. Some \$26 million has been saved on the painting of 100 Kentucky bridges when compared to the national cost average. This represents a research investment return of approximately 100 to 1.



**Number Three:      Embankment Construction Using Shale**  
[Ref. #'s KYSPR 85-107 and KTC 98-2]

### Resources

Project Leader – Tommy C. Hopkins, PE  
Study Advisory Committee Chair – Jim Stone  
Investment Amount – \$386,200  
Duration – 1985-1998



## Objectives and Results

Certain areas in Kentucky have highway embankments consisting largely of shale. Numerous and costly shale embankment failures occur some 1-10 years after construction. Each year, millions of dollars have been spent repairing shale embankments in Kentucky (sections of I-75 and I-71 in Northern Kentucky have averaged \$2 million per mile in past years). **The primary objective of this study was to evaluate an experimental shale compaction specification that was applied to three shale embankments through long-term performance monitoring.** The field tests and long-term observations confirmed that the experimental compaction specification improves slope stability and greatly reduces long-term settlement. The use of this new compaction specification can avoid the costly effects of shale embankment settlement and failure. The study also confirmed the use of a 'slake-durability' test for use in identifying shale of poor engineering quality.

## Implementation and Benefits

The KY Transportation Cabinet has officially adopted the special shale compaction specification and it has been incorporated in the agency's 'Standard Specifications for Road and Bridge Construction.' The 'slake-durability' test as proposed by the Center is now used routinely to identify shale with poor engineering properties in Kentucky. By preventing settlement and slope instability the special shale compaction specification is saving the agency millions of dollars in maintenance funds annually. The new AA-highway used the special compaction specification and no major embankment failures or settlements have occurred since construction. The estimated cost savings is approximately \$170 million when compared to the I-55 and I-71 experience with roadway segments passing through the same geological formations.



**Number Four:      Rock Scour Around Bridge Piers and Abutments**  
[Ref. #'s KYSPR 94-157 and KTC-99-57]

Resources

Project Leader – Tommy C. Hopkins, PE  
Study Advisory Committee Chair – Daryl Greer  
Investment Amount – \$320,696  
Duration – 1994-1999

Objectives and Results

The catastrophic collapse of two spans of the Interstate 90 bridge over Schoharie Creek near Amsterdam, NY in 1987 was due to the under mining (scour) of a supporting pier. This prompted numerous investigations of bridges throughout the country to determine the vulnerability due to scour. The objectives of this study were to:

- Determine the extent of rock scour at bridge footers in Kentucky;
- Establish a correlation of scour depth with a standard Rock Quality Designation (a rock drilling test); and
- Recommend an appropriate level of monitoring and analysis in light of FHWA guidelines.

Data collected in this study showed that rock scour was not a significant problem in Kentucky. A correlation with a standard test was established that alerts

designers to dangerous rock scour situations. Having an inspection program to periodically observe and monitor footers of bridge piers (and culverts) was found to be sufficient in safeguarding against rock scour failures in Kentucky.

### Implementation and Benefits

The correlation of the Rock Quality Designation test and rock scour depth that was developed has been adopted as part of the design procedure for determining depth of footers for bridge piers and abutments. (When the 'RQD' value is less than 25 percent, the correlation shows that precautionary measures should be taken in positioning footers.) Some 70 percent of the existing Kentucky bridge/culvert footers are on bedrock, as shown by this study. The performance of rock scour analysis in accordance with the FHWA guidelines is not necessary at these locations. Elimination of these unnecessary analyses will save in excess of \$30 million.



### **Number Five:            Intelligent Transportation Systems Strategic Plan** [Ref. #'s SPR-97-188 and KTC-98-9 and KTC-00-5]

#### Resources

Project Leader -- Jerry Pigman, PE (with Joe Crabtree, PE)  
Study Advisory Committee Chair – Chuck Knowles  
Investment Amount – \$140,353  
Duration – 1997-1998

## Objectives and Results

Intelligent Transportation Systems (ITS) technologies offer the potential to revolutionize surface transportation over the next 10-20 years. Tremendous improvements in safety, comfort, speed, and efficiency are possible through the wise use of ITS. However, deployments of ITS technologies can suffer greatly if they are not well-planned or well-coordinated. Therefore, the Kentucky Transportation Cabinet asked the Center to develop Kentucky's ITS Strategic Plan.

The objectives included:

- Focusing on the nationally designated areas of ITS (and giving initial priority to the first three below)
  - Rural transportation systems
  - Traveler information systems
  - Commercial vehicle operations
  - Traffic management systems
  - Vehicle control systems
  - Public transportation systems
- Determine mission, vision, goals and potential technology applications (for each area listed above)
- Identify ITS issues of importance to Kentucky and their relationship to initiatives already underway

Background information was solicited and received from 11 states that have completed ITS Strategic Plans. Plan development activities brought together more than 100 stakeholders from throughout the Commonwealth and a set of goals was developed for each of the ITS areas. In addition, discussions and recommendations were included regarding public relations & marketing, operations & maintenance, and organization structure for ITS in Kentucky,

## Implementation and Benefits

The goals established, with the various stakeholders, provides sound direction for the selection of coordinated development 'packages' and specific ITS projects. Deployment in accordance with the plan assures a more coordinated approach that meets user needs. It promises a higher return on investment and a better match with stakeholder needs and expectations. A 'business plan' that schedules and packages ITS project investments is underway.



**Number Six:           Evaluation of Experimental Hot-Mix Asphalt  
SUPERPAVE Projects**  
[Ref. #'s KYSPR-98-183 and KTC-99-53]

Resources

Project Leader – John Fleckenstein, PG  
Study Advisory Committee Chair – Allen Meyers  
Investment Amount – \$133,720  
Duration – 1998-1999

Objectives and Results

Over 90 percent of all highway pavements in the US are surfaced with hot-mix asphalt. Over many decades these pavements were designed using the 'Marshall mix' procedure. Nationally sponsored asphalt pavement research beginning in 1987 resulted in a new (experimental) asphalt mix design procedure called SUPERPAVE. Kentucky utilized this experimental mixture for the first time in 1995. This project was established to evaluate the early SUPERPAVE projects in Kentucky and specifically to:

- Develop a database of performance characteristics to assist in prediction models;
- Evaluate the construction practices; and
- Undertake a life-cycle cost analysis.

A total of 24 SUPERPAVE and 14 Marshall projects were evaluated during or shortly after construction. A detailed construction data base was established providing information on achieving compaction, avoiding the 'tender zone' (an area which is difficult to compact), benefits of material-transfer vehicles, avoiding aggregate and thermal segregation, and determining appropriate mixing and compaction temperatures. Analysis concluded that: (1) the Marshall mixture projects are more prone to bleeding, rutting, and other surface distresses; and (2) the SUPERPAVE mixtures perform better overall. Construction costs appear to be substantially the same. Longer term monitoring is necessary to better understand the possible performance differences of these design methods for an effective life-cycle costing analysis.

### Implementation and Benefits

In 2000 the KY Transportation Cabinet made the SUPERPAVE specification mandatory for all hot-mix asphalt projects. The project has provided valuable information for the design and construction of SUPERPAVE mixtures and pavements. Documentation of the design and construction experience and the associated costs will provide a sound basis for future design and life-cycle cost analysis (the needed long-term monitoring is continuing). Some national research has recently indicated that SUPERPAVE specification pavements may last from three to four years longer before an overlay is necessary. Assuming a four-year pavement life extension and the resulting change in rehabilitation cycles, a savings of \$118,800 per mile for a 1.5-inch overlay (\$40/ton) on a four-lane highway could be expected.



**Number Seven: Evaluation of Pavement Edge Drains and the Effect on Pavement Performance**

[Ref. #'s KYHPR 92-143 and KTC-97-5]

Resources

Project Leader – David Allen, PE  
Study Advisory Committee Chair – Gary Sharpe  
Investment Amount – \$309,967  
Duration – 1992-1997

Objectives and Results

There is a critical need for good drainage of highway pavement. According to the Asphalt institute's Handbook "...no other feature is as important in determining the ability of a pavement to withstand the effects of weather and traffic."

Especially important is the subgrade, the area below the pavement layer.

Pavement edge drains are designed to facilitate that drainage. This study had several objectives relating to pavement edge drains as follows:

- Quantify the major in-service problems
- Develop a generic specification
- Determine the lateral effectiveness
- Verify improved pavement performance with use
- Determine cost effectiveness of use

A comprehensive range of some 24 in-service problems was identified and recommendations were proposed for each. A generic specification was

developed and with few modifications has been adopted by the agency. Testing and analysis indicated that edge drains significantly increase the strength of the subgrade through removal of water. This has a significant impact on long-term performance of roadways having edge drains.

### Implementation and Benefits

Several design and construction changes were implemented by the agency as a result of this research. A unique laboratory testing procedure was developed in this study and adopted by the national standards association, as ASTM (D6244-98 "Test Method for Vertical Compression of Geocomposite Pavement Panel Drains"). Also, the camera inspection methods developed to evaluate in-place edge drain systems were adopted by the agency as part of the quality control procedure (QC Specification). Since the initiation of the recommended design and construction changes the failure rate has been reduced from 20 to 24 percent. Given previous long-term performance information (life-cycle cost analysis for a 40-year design) a cost savings of \$240,000 per mile can be expected. In addition, the changes in design and construction recommended by this research should increase the performance of the roadway system.



**Number Eight:      The Motor Fuel Tax Evasion Issues and  
Recommendations to Reduce Evasion**  
[Ref. #'s UKSPR-93-153; KTC-97-14 and KTC-97-16]



## Resources

Project Leader – Dwight Denison, PhD (with Merl Hackbart, PhD)  
Study Advisory Committee Chair – Glenn Mitchell  
Investment Amount – \$143,993  
Duration – 1993-1997

## Objectives and Results

Motor fuel tax evasion has proven to be a growing and somewhat elusive problem. Part of the difficulty is the fact that road fund taxes (base on fuel purchases) are collected through governmental partnerships (federal-state-local) and their cooperative efforts. The study objectives included:

- Estimating the level of evasion in Kentucky;
- Determination of the methods of evasion;
- Investigating legislative actions taken by southern states; and
- Developing strategies for mitigating evasion.

The study resulted in two reports. The first provided seven recommendations for reducing evasion and increasing road fund revenues that ranged from participating in regional task forces with other states to considering the benefit of additional field auditors. The second report provided recommendations ranging from the redesign of license plates for better recognition to changing laws so that corporate officers would be held responsible for the evasive actions of their organizations.

## Implementation and Benefits

This research has added substance to the discussion of motor fuel tax evasion and a basis for rational action. Concepts have and are being considered based on the experience of laws already passed in other states. There is ongoing consideration being given to statutory changes in Kentucky. Recommendations have resulted in adjustments to the road fund tax collection and administration procedures including audit staff functions and activities. A special 'revenue analysis unit' was established in 2000 to provide audit assistance; conduct statistical sampling and develop a data base; and build a liaison with federal and other states' agencies. This hands-on unit is expected to produce immediate results in reducing tax evasion.



**Number Nine: Freight Movement and Intermodal Access In Kentucky**

[Ref. #'s SPR-98-189; KTC-98-14; KTC-99-48; and KTC-99-65]

Resources

Project Leader – Lisa Aultman-Hall, PhD  
Study Advisory Committee Chair – Chuck Knowles  
Investment Amount – \$401,135  
Duration –1998—1999

Objectives and Results

This study had a series of objectives that included:

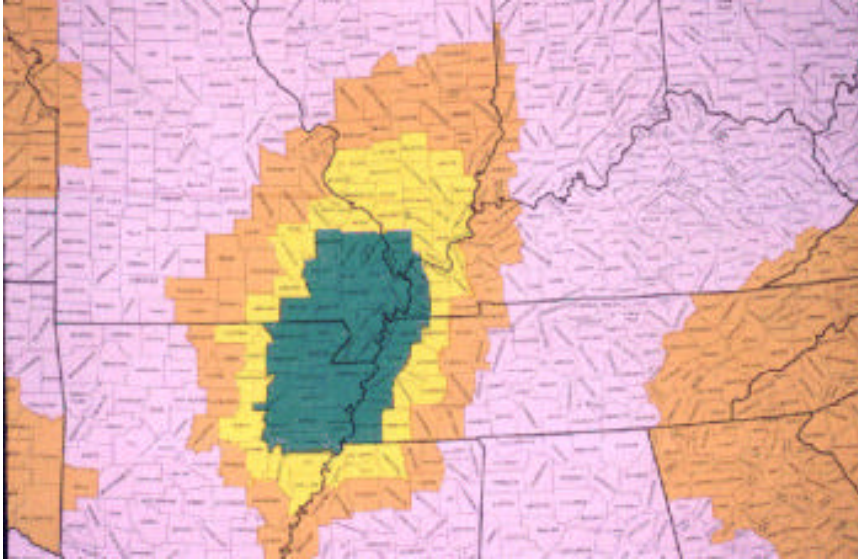
- Develop a method to determine access capability of the state's highway system for trucks traveling between intermodal or other facilities and the National Highway System (NHS)
- Evaluate the access capability of heavily used roadway segments for trucks connecting to the NHS
- Develop an understanding of current freight commodity flows throughout the state

An approved methodology was developed to allow researchers to focus on actual problems being experienced on the different kinds of highways in various jurisdictions. The methodology provides actual rankings of points along a route

and an urgency rating based on truck volume and the length of the route. Some 46 truck 'generating' sites with their associated 81 routes and 800 miles of roadway connecting to the NHS were evaluated. Specific recommendations for maintenance and reconstruction were made. Ten of the 81 routes were considered adequate while the other 71 were recommended for various improvements in a priority order. It was proven possible to determine the commodity flows in the state. Information regarding the type and quantity of freight commodities flowing to and from different areas of the state was provided. The analysis also considered the relative amount of by-pass freight as well as the distribution of freight among the various modes. There is a variety of disparate data sources, but reliable compiled proprietary data are available for purchase. A commodity flow dataset would be beneficial to the statewide traffic model. Specific forecasts of truck traffic volume are important for long-range highway planning and truck monitoring facility location. However the study indicated that improvements are needed in how the data is zoned within Kentucky and in surrounding states.

### Implementation and Benefits

This research study allows the agency to readily identify specific problem locations on a system-wide basis that provides initial priority for consideration in the six-year plan for highway improvement. In addition, it sets the stage for improved traffic forecasting with a special commercial vehicle component should the agency want to pursue it. The short and longer-term promise is systematic improvements in the highway system that would reduce congestion and improve safety relating commercial vehicle traffic.



**Number Ten: Seismic Rating and Evaluation of Highway Structures**  
[Ref. #'s SPR-96-173 and KTC-97-1, KTC-98-1, KTC-98-20,  
KTC-99-16, KTC-99-17]

#### Resources

Project Leader – Issam Harik, PhD (with David Allen, PE)  
Study Advisory Committee Chair – Don Herd  
Investment Amount – \$455,250  
Duration -- 1996-1999

#### Objectives and Results

A 90 percent probability exists that a major earthquake will occur along the New Madrid fault within the next 50 years. A number of bridges over the Ohio River and other highway structures are located in areas that would be affected by such an earthquake. This study had the following three major objectives:

- Generate dynamic site periods due to seismic loading at bridge sites in the portion of Kentucky that is west of the Tennessee River;
- Conduct seismic stability assessment of highway bridge approach embankments and retaining structures; and
- Conduct dynamic testing and seismic evaluation of the US 51 and the twin US 41 truss bridges crossing the Ohio River in Western Kentucky.

The ranking of highway embankments for western Kentucky designated six embankments that may be at serious risk of failure for a 50-year seismic event (i.e. an event with a 10 percent probability of being exceeded in the next 50

years). The evaluation of the US 41 and US 51 bridges indicated that the superstructure of the main bridges will withstand the 50-year earthquake event without any damage however, a number of supports on the piers of the main bridges and supports having fixed bearings on the approach spans require retrofit.

### Implementation and Benefits

Based on the findings from the seismic analysis, recommendations for retrofit were made for the bridges, and implementation of the retrofit is under evaluation. The benefits of this study can be measured by considering the effects a major earthquake would have on the bridges, highway structures, and the surrounding communities. The repair of collapsed major bridges will exceed \$10 million per bridge. Furthermore, the closure of US 41 and US 51, which are economic thoroughfare linking western Kentucky to Illinois and Indiana, would result in economic losses in the millions of dollars per day. Retrofit of the bridges will ensure that they will withstand a 50-year event.

### **Number Eleven: Heavy Truck Involvement in Traffic Accidents and Related Countermeasures**

[Ref. #'s KYSPR 98-181, KTC-98-5, and KTC-99-20]

### Resources

Project Leader – Jerry G. Pigman, PE  
Study Advisory Committee Chair – William Madden  
Investment Amount – \$184, 474  
Duration – 1998-1999

### Objectives and Results

Crashes involving heavy trucks are more severe and represent higher percentages of fatal crashes than those involving other types of vehicles. In Kentucky, trucks are involved in about 7 percent of all crashes, but are involved

in approximately 13 percent of the fatal crashes. This project had three research objectives:

- Investigate and analyze traffic accidents (and locations) involving trucks
- Examine the relationship between heavy loads and truck braking efficiency
- Recommend countermeasures to reduce the number and severity of these type accidents

Two reports were issued covering the findings of this research project. The first included the analysis of crash data for a three-year period and identified the unique characteristics of truck accidents. A detailed analysis was conducted for all fatal crashes involving a truck. Critical rate sections of highways were identified. Field tests were conducted to determine the effect of increased loads on the ability of a truck to brake to a stop and determine if trucks could meet the requirements of the Federal Motor Carrier Safety Regulations. The second report included an additional year of crash data and each crash was classified by type and causative factor. Countermeasures were recommended to reduce specific types of crashes. Locations were identified and case studies were conducted of the higher rate sites. The US 23 highway (in Lawrence Co.) was analyzed using data from a weigh-in-motion detector and specific recommendations were made relating to coal truck weight limits and the enforcement mechanism.

### Implementation and Benefits

The range of recommendations to reduce truck crashes included countermeasures relating to the vehicle, roadway, and driver. Among those pertaining to the vehicle was a recommendation to use infrared or performance brake testing. In 2000 the Kentucky Transportation Cabinet began participating in a multi-state test of the infrared technology and it has proven very reliable in identifying trucks with brake problems. Another recommendation having to do with the roadway called for increased truck parking/rest facilities. Again, the agency has recently provided more parking and has designated 'rest havens' for truckers on the interstates. Two other recommendations—to install centerline rumble strips and advance traffic signal warning flashers—for areas with a high percentage of truck traffic have been implemented by the agency in selected

locations. While the actual reduction in crashes or fatalities from implementing recommendations such as these cannot be documented, it is clear that major benefits accrue with every crash or fatality that is avoided. Each injury involving crash avoided is a savings of between \$15,300 and \$39,500 and each fatality avoided is a savings of between \$970,000 and \$3,100,000 on the average.







## APPENDIX

### Research Project Abstracts by Year of Completion (and Research Program Area)

#### Numbers Note:

Research projects during the five-year period of this report typically have three numbers closely associated with them. The first, is a project reference number (SPR [or in 1995, HPR]-00-00) that is assigned to a project when it is commissioned by the client. Numbers are also assigned to individual research reports as they are issued (KTC-00-00). One project may have multiple reports. In addition, a project when commissioned receives a budget number that may change over the duration of the project. The actual total project investment is listed in this appendix with each report/abstract. This does not necessarily reflect the cost of research behind a single report.



# 1999

## **ENVIRONMENTAL ANALYSIS**

**KTC-99-2      “Development of an Information Management System for Assisting Kentucky  
SPR-96-168      Transportation Cabinet Personnel Concerning Environmental Issues,” Bobby  
Meade, \$133,468 (Pending with Cabinet), SAC - H. R. Renaud**

### **ABSTRACT**

A PC-based information management system was developed to assist Kentucky Department of Highways (KyDOH) personnel in addressing environmental issues. KyDOH had, at the time of system development, two central offices responsible for implementing environmental regulations developed by the Natural Resources and Environmental Cabinet (NREPC). The Transportation Environmental Information Management System (TEIMS) facilitates the dissemination of central office expertise and procedures to the twelve district offices that implement the procedures developed by the central offices. TEIMS also provides an “expert system” to assist in some decision-making and links with various other software to provide word processing, database, mapping, and electronic mail functions.

**KTC-99-52      “Assessment and Modeling of Stream Mitigation Procedures,” Bobby Meade,  
SPR-99-193      \$64,308, SAC - Keith Crim**

### **ABSTRACT**

This study evaluates the construction and performance of KyDOH stream disturbance mitigation projects. The initial study tasks were to conduct a literature search, review of stream performance models, a review of Kentucky’s and other agency’s regulations pertaining to stream mitigation, identification of representative stream mitigation projects, and evaluation of those sites. The results of this study will produce a tool for evaluating stream mitigation projects after they are constructed.

## **GEOTECHNOLOGY**

**KTC-99-57      “Correlation of Rock Quality Designation and Rock Scour Around Bridge Piers  
SPR-94-157      and Abutments Founded on Rock,” Tommy C. Hopkins, \$320,696, SAC - Daryl  
Greer**

### **ABSTRACT**

Local scour around the base of a bridge pier or abutment occurs as the result of flow acceleration around the obstruction, formation of a vertical pressure gradient along the upstream end, and generation of vortices at the base of the structure. The potential for local scour at a bridge pier or

abutment needs to be estimated so that foundations can be designed to resist failure during large floods. While procedures have been suggested for estimating local scour depths at bridge piers and abutments located on, or in unconsolidated alluvial material, only interim FHWA guidelines (July 1991) in the form of a memorandum are available for evaluating the scour potential at footings placed on rock. The empirical guides relate quantifiable geotechnical indices to a qualitative measure of the ability of the foundation rock to resist erosion. However, the procedure lacks documented proof or verification by means of either experiment or observation. To test the validity of some of the more significant FHWA guidelines for assessing the rock scour, on-site inspections of some 400 bridges with footings located on exposed rock were performed. A large number of bridge abutments and piers in Kentucky were found to have been placed on rock foundations that are visible during low flow. These inspections show that scour at bridge piers and abutments placed on rock does occur, but based on the inspections, rock scour is not a significant problem in Kentucky. [Statistically, only about 0.5 percent of the observed bridges had significant vertical scour.] An approximate relationship between vertical rock scour depth next to the abutment, or pier, and rock Quality Designation (RQD) was developed. Also, an approximate relationship between horizontal rock scour penetration beneath a pier, or abutment, footer and Rock Quality Designation (RQD) is presented.

## **PAVEMENTS AND MATERIALS**

**KTC-99-1      “Development of ESAL Forecasting Procedures for Superpave Pavement  
SPR-99-194    Design,” Brad Rister, \$34,883, SAC - Rob Bostrom**

### **ABSTRACT**

This report documents the analysis methods used to develop the Equivalent Single Axle Load (ESAL) forecasting program for Superpave projects. In addition, this report discusses the procedures used in the ESAL forecasting program to forecast ESALs in the design lane for pavement resurfacing/overlay projects which are consistent with the Superpave process of asphaltic mixture design.

**KTC-99-53      “Evaluation of SUPERPAVE in Kentucky,” John Fleckenstein, \$50,212,  
SPR-98-183    SAC - Allen Myers**

### **ABSTRACT**

Approximately 93 percent of all pavements in the United States are surfaced with hot-mix asphalt (HMA). For many decades, most asphalt pavements were designed using the Marshall mix design method. In 1987, the Strategic Highway Research Program was established with \$50 million being allocated for asphalt pavement research. From that research, a new asphalt mix design procedure, called Superpave, was developed. Many states have adopted, or are in the process of adopting, this procedure, including Kentucky. In 1995, Kentucky placed its first Superpave mixture on KY 676 in Franklin County. In 1998, the Kentucky Transportation Cabinet requested that the Kentucky Transportation Center (KTC) evaluate the Superpave projects in Kentucky. The objectives of this

study were to develop a database of performance characteristics to assist in the development of prediction models for Superpave, to evaluate construction practices involving superpave projects, and to attempt to perform a life-cycle cost analysis for Superpave projects.

**KTC-99-59     “Economic Impact of Heavy Loads On the Highway Infrastructure,” David  
SPR-95-162     Allen, \$270,043, SAC - Gary Sharpe**

## **ABSTRACT**

During the 1986 General Assembly the Extended-Weight Coal Haul Road System was created by the Kentucky State Legislature. This system was defined to include those highways where more than 50,000 tons of coal had been hauled during the previous year. Trucks hauling coal on the extended-weight system were authorized to exceed the normal weights limits through the payment of an annual decal fee.

In efforts to identify the benefactors of the extended coal haul system legislation, this study has been conducted to identify the overall economic impact of hauling heavier total gross weights by coal truck on the highway infrastructure in Kentucky in 1996. In order to identify the overall economic impact of hauling heavier weights by coal truck an economic analysis had to be preformed. This economic analysis compared the monetary benefits derived by all users for hauling heavier weights by coal truck to the additional expenses incurred by allowing heavier weights to be hauled on the highway infrastructure. The findings of this study include data for 1996 indicating that the average gross weight of trucks hauling coal was 158,000 lbs. The estimated economic benefit resulting from hauling approximately 93 million tons of coal with these heavier loads was \$8.2 million. However, there was also an additional expense for maintaining and operating the coal haul routes of \$3.2 million (exclusive of bridges).

## **POLICY AND SYSTEMS ANALYSIS**

**KTC-99-65     “Freight Commodity and Intermodal Access in Kentucky - Freight Movement  
SPR-98-189     and Intermodal Access in Kentucky,” Lisa Aultman-Hall, \$187,076, SAC - Carl  
Dixon and Bruce Siria**

## **ABSTRACT**

The primary objectives of this project were to further the understanding of freight flows throughout Kentucky and to make recommendations on the potential value of freight commodity flow data as an input for statewide transportation planning models. Freight flow data are difficult to accumulate and to convert to common units for use. However, the data available from Reebie Associates that were developed with the Federal Highway Administration have proved useful. The database itself was found to be consistent with other sources of aggregate freight data for Kentucky except for airports. The data assigned to the highway network was in general agreement with weigh station counts and previous research conducted by Morehead State University. However, modeled truck volumes were

found to have poor correspondence with the 1996 KyTC classification counts particularly for non-freeway routes. These errors are attributed to the large zone size (e-digit zip code) used in the model as well as the representation of Tennessee as a single zone. Specific recommendations are made for KyTC's consideration for future freight transportation planning efforts.

**KTC-99-50     “Kentucky’s Road Fund Tax Structure,” Merl Hackbart, \$24,937, (Pending  
SPR-99-191     with Cabinet) SAC - Glenn Mitchell**

## **ABSTRACT**

In recent years, there has been a great deal of discussion of whether the incoming Road Fund revenue is sufficient to meet the needs of Kentucky’s Highways System. Many have suggested a policy of raising the current tax rates on motor fuels as a way of enhancing the financial health of the Road Fund. This current study examines the sources of the Road Fund and evaluates the sources of revenue in terms of stability, equity, competitiveness, and adequacy. Finally, the study examines the impact various changes in motor fuel taxes would have on revenue.

## **STRUCTURES**

**KTC-99-16     “Seismic Evaluation of the US41 NORTHBOUND Bridge over the Ohio River  
SPR-96-173     at Henderson, Ky,” Issam E. Harik, \$516,611 (Other reports include: KTC 99-17,  
KTC 98-20, KTC 98-1, and KTC 97-1), SAC - Donald Herd**

## **ABSTRACT**

This report presents the seismic evaluation of the US41 Northbound bridge over the Ohio River connecting Evansville, Indiana and Henderson, Kentucky. The main bridge is a four-span cantilever through-truss type. The approach bridge has eight spans on the Evansville, IN side and 35 spans on the Henderson, KY side. Although this bridge has not yet been subjected to a moderate or major earthquake, it is situated within the influence of the New Madrid and Wabash Valley Seismic Zones.

The seismic evaluation program consisted of field testing and seismic response analysis. The modal properties of the main bridge were determined through field testing, and were used to calibrate a three dimensional finite element model. The finite element model was then subjected to time histories of the 50-year earthquake event. Stresses and displacements obtained were found to be within the acceptable limits. Analytical results indicate that the superstructure of the main bridge will survive the projected 50-year earthquake without any damage and no loss-of-span.

However, all supports on the piers of the main bridge require additional anchor bolts or seismic isolation bearings.

The approach spans were analyzed using response spectrum method with simplified single-degree-of-

freedom models. Thirteen out of 42 supports having fixed bearings on both the Kentucky and Indiana approach spans require additional anchor bolts at the fixed bearings or seismic isolation bearings.

**KTC-99-17      “Seismic Evaluation of the US41 SOUTHBOUND Bridge over the Ohio River  
SPR-96-173      at Henderson, Ky,” Issam E. Harik, \$516,611 (Other reports include: KTC 99-16,  
KTC 98-20, KTC 98-1, and KTC 97-1), SAC - Donald Herd**

## **ABSTRACT**

This report presents the seismic evaluation of the US 41 Southbound bridge over the Ohio River connecting Evansville, Indiana and Henderson, Kentucky. The main bridge is a four-span cantilever through-truss type. The approach bridge has nine spans on the Evansville, IN side and 20 spans on the Henderson, KY side. Although this bridge has not yet been subjected to a moderate or major earthquake, it is situated within the influence of the New Madrid and Wabash Valley Seismic Zones.

The seismic evaluation program consisted of field testing and seismic response analysis. The modal properties of the main bridge were determined through field testing, and were used to calibrate a three dimensional finite element model. The finite element model was then subjected to the acceleration time histories of the 50-year earthquake event. Stresses and displacements due to projected earthquakes are found to be very low. Analytical results indicate that the main bridge superstructure will survive the projected 50-year earthquake without any damage and no loss-of-span. However, all the supports on the piers of the main bridge require additional anchor bolts or seismic isolation bearings.

The Kentucky and Indiana approach spans are analyzed using the response spectrum method with simplified single-degree-of-freedom models. Ten out of twelve supports having fixed bearings on both the approach spans require additional anchor bolts or seismic isolation bearings. At three out of 25 supports having expansion bearings, the existing rocker bearings need to be replaced with elastomeric bearings or cable restrainers need to be provided to avoid loss-of-span.

**KTC-99-22      “Laboratory Testing and Analysis of Joints for Rigid Pavements,” Issam E.  
SPR-96-171      Harik, \$286,433, SAC - Gary Sharpe**

## **ABSTRACT**

The primary objective of this study was to analyze the concrete pavement system under nonlinear temperature distribution and vehicle wheel loading,. The jointed concrete pavement system consists of concrete slabs with transverse and longitudinal joints, dowel bars (across transverse joints), tie bars (across longitudinal joints), subbase and subgrade soil. Under the loading conditions the pavement structural system may fail by cracking of the concrete slab, loss-of-support of slab due to temperature induced curling, closing and opening of joints, and failure of load transfer devices such as dowel bars, etc. In order to understand the cause of these failures or to achieve an economical design, the state of stress in the pavement system should be determined. It is very difficult to predict the stresses accurately in the pavement system with discontinuities and complex support conditions using

conventional classical methods. Therefore, this project uses the ANSYS finite element software.

A literature review was performed to identify and evolve an accurate finite element model. It was found from this review that there were difficulties in incorporating the dowel-concrete interface, loss-of-support, contact conditions at the joints, nonlinear temperature distribution, etc. Since there has been no systematic comparison between the experiment and theoretical analysis in the past, the present study conducted the following laboratory testing to determine the respective stiffness quantities: 1) Doweled concrete blocks under bending and shear load, 2) Concrete blocks with tie bars under bending and shear load, 3) Concrete blocks with aggregate interlock joints under shear load, and 4) Concrete blocks with sealed joints under shear load. The stiffness values derived from these testing procedures is to be used in the evolution of a finite element model for the concrete pavement system.

In addition to this, it is recommended that field measurement of temperature distribution through the thickness of the slab be performed. Finally, a full-scale field testing using FWD is also recommended. The test results obtained from this full-scale testing could be used to assess the validity of the finite element model.

## ***TRAFFIC AND SAFETY***

***KTC-99-20     “Heavy Truck Involvement in Traffic Accidents,” Jerry G. Pigman, \$62,158,  
SPR-98-181    SAC - William Madden***

### **ABSTRACT**

The objectives of this research study were to conduct a detailed analysis of truck accidents and recommend countermeasures to reduce the number and severity of this type of accident. Police reports for fatal accidents in which a truck was involved were reviewed for the period 1994 through 1997. Each accident report was reviewed and classified into types of accidents and causative factor categories. The most common accident involved another vehicle crossing the centerline into the path of a truck. The primary causative factor was related to the actions of the other driver, rather than the truck driver, in nearly two-thirds of the accidents. Countermeasures were recommended to reduce specific types of accidents. Locations were identified with the highest number of specific types of accidents and case studies were conducted to offer recommended solutions.

Data from a weigh-in-motion site on US 23 in Lawrence County was analyzed and summarized to show the pattern of loads being carried by coal trucks in eastern Kentucky. Results were used to offer data which could support revisions to the current weight limits for the Extended-Weight Coal Haul Road System for combination trucks and to develop an enforcement mechanism which could improve compliance. Data summarized by the Transportation Cabinet's Division of Vehicle Enforcement was also collected and summarized to show the results of commercial vehicle inspections and the adjudication process for citations issued.

Recommendations were made to reduce the number and severity of truck accidents. They included



countermeasures relating to the vehicle, roadway, and driver.

**KTC-99-23**     *“Evaluation of Kentucky’s Driver License Renewal Process,” Nick Stamatiadis,*  
**SPR-98-184**     *\$149,082, SAC - Steve Coffey*

#### **ABSTRACT**

The objectives of this research were to first evaluate the existing practices regarding driver license renewal, driver retesting, and medical review board procedures and then identify and recommend methods that would improve these processes. The analysis of the Medical Review Board process indicated that, while it operates at an acceptable level in major urban areas, it is almost non-existent in most areas of the state. A brochure describing the process was developed for distribution to physicians. There is a universal agreement among researchers that vision has a significant role in driving performance and that visual abilities deteriorate with age. It is apparent that some type of vision screening should be implemented during the renewal process since it could identify individuals with potential deficiencies. Such screening could be achieved either with a test during the license renewal or with an eye exam prior to license renewal. In addition to the testing, a policy that identifies potential at-risk drivers should be considered. The combination of convictions (points) and crashes was considered as an appropriate means to distinguish such drivers. Special consideration should be given for older drivers at driver license renewal. In addition to the vision screening, a written test could be administered at license renewal along with a set of medical questions to determine their physical and mental status.

**KTC-99-48**     *“Final Summary Report on ‘Truck Route Access Evaluation,’ Freight*  
**SPR-98-189**     *Movement Intermodal Access in Kentucky,” Lisa Aultman-Hall, \$187,076, SAC -*  
*Carl Dixon and Bruce Siria*

#### **ABSTRACT**

This report summarizes the evaluation of truck route access between the National Highway System and 46 truck generating sites, including intermodal sites, throughout Kentucky (includes 81 routes and 800 miles of highway). Routes were evaluated quantitatively for nine highway features, assigned an overall route rating and recommendations for routine maintenance and re-construction were made. The level and quality of truck access to the NHS varies dramatically throughout the state. Some facilities are between 25 and 50 miles from the NHS. No significant difference in route ratings or other measures was found by geographic location. The different topography throughout the state contributed to differences in grade and curvature quality. Very few non-NHS truck routes have 12-foot lanes along their whole length. The intermodal facility routes in general were found to be of better quality than routes leading to truck only sites. Trucks are not always using the routes they should. Ten of the routes were considered the “best” and required no improvements at this time. Improvements on other routes varied from routine maintenance to the need for complete reconstruction. Routes were prioritized by length and amount of truck traffic to recommend the most critical routes for improvement.

## **TECHNOLOGY TRANSFER**

**KTC-99-3**      *“Employee Satisfaction Survey,” Bennett Tepper and Patsy Anderson, \$35,824,*  
**SPR-99-203**    *SAC - Chuck Knowles*

### **ABSTRACT**

The purpose of this survey was to establish the baseline attitude of Kentucky Transportation Cabinet employees concerning work environment and morale.

## **1998**

## **CONSTRUCTION MANAGEMENT**

**KTC-98-18**      *“Cost Estimating and Forecasting for Highway Work in Kentucky,” James D.*  
**SPR-94-158**    *Stevens, \$235,873, SAC - Charles Raymer*

### **ABSTRACT**

Starting 1 July 1992, KRS45.245 granted the Interim Joint Committee on Transportation oversight of the biennial highway plan, including a review of all authorized highway project phases that exceed their estimates by 15 percent

Estimates developed using current methods were not sufficiently accurate to preclude cost overruns in excess of 15 percent. Estimates were prepared before design began in order for the project to be included in the six-year plan. These estimates were not revised after a more detailed scope was available.

There were 562 overruns in excess of 15 percent at a cost of approximately \$265 million during the period 7/1/92-7/1/98. All overruns were approved for the necessary additional funding. The requirement for review of overruns in excess of 15 percent was canceled by the General Assembly (HB655) effective 1 July 1998.

There was a need for better cost estimating and forecasting for highway work in the Commonwealth of Kentucky. This research effort studied the causes of the 562 cost overruns in excess of 15 percent and attempted to improve the conceptual estimating process. A computerized conceptual estimating model, KYEstimate, was developed to assist estimators in preparing and justifying conceptual estimates that must be made prior to detailing scoping of projects. Recommendations and conclusions are presented

## **GEOTECHNOLOGY**

**KTC-98-2**      *“Embankment Construction Using Shale,” Tommy C. Hopkins, \$60,000 , SAC*  
**SPR-85-107**   *Jim Stone*

### **ABSTRACT**

Shales have been used extensively in the construction of highway embankments, and other earthen structures, because of the vast amounts of these materials located in many areas of the country and the lack of economical and alternate available materials. Because shales exhibit a wide range of engineering properties and behaviors, many problems have occurred. Numerous shale embankment failures have occurred generally some one to ten years after construction. Settlements of one to three feet (0.3 - 0.9 m) have been observed in many old embankments and required numerous asphaltic overlays. Shale embankments that settle continuously have been observed to fail eventually. Each year millions of dollars are spent repairing embankments built with shales. This report presents a discussion of some of the research conducted by the University of Kentucky Transportation Center in the seventies and eighties and attempts to address some of the problems that arise in constructing shale embankments. A brief overview of the engineering properties of shales located in Kentucky is presented. Some important factors that need to be considered in designing and building shale embankments are briefly discussed. Finally, a description of the construction of three experimental shale embankments in 1986 is given. These embankments were constructed to evaluate a special shale compaction provision adopted by the Kentucky Transportation Cabinet to avoid large long-term settlements and instabilities. Observations of long-term settlements of the embankments are presented.

## **PAVEMENTS AND MATERIALS**

**KTC-98-21**      *“Analysis of Vehicle Classification Data, Including Monthly and Seasonal*  
**SPR-95-161**      *ADTFactors, Hourly Distribution Factors, and Lane Distribution Factors,”*  
*David L. Allen , \$118,095, SAC - Rob Bostrom*

### **ABSTRACT**

This report documents the development of monthly and seasonal ADT factors for performing estimating AADT's. It appears that seasonal factors can estimate AADT as well as monthly factors, and it is recommended that seasonal factors be used.

Hourly distribution factors were also developed in this study. These are to be used in life-cycle costing analyses for calculating queue lengths in estimating user delay costs.

In this study, a comparison was made between automatic vehicle classification counters and manual counts. For the type of equipment used, automobiles were overestimated, pickup trucks were underestimated, and Type nine's were also underestimated.

Lane distribution factors were developed in this study. The factors were developed as a function of

ADT and percent of trucks.

## **STRUCTURES**

**KTC-98-1**      *“Seismic Isolation of A Highly Skewed Prestressed Concrete Girder Bridge,”*  
**SPR-96-173**    *Brad Robson, \$516,611, (Other reports include: KTC 99-17, KTC 99-16, KTC 98-20, and KTC 97-1), SAC - Donald Herd*

## **ABSTRACT**

A relatively new approach for designing or retrofitting highway bridges in seismic zones involves isolating the superstructure from the substructure. Through experimental and analytical investigations, this study evaluates the effectiveness of isolating one particular bridge: a highly skewed, prestressed concrete, slab-on-girder bridge. Dynamic testing of the bridge was performed using the pullback, quick-release method. A three dimensional finite element model of the bridge was created. It was refined, or calibrated, to match experimentally determined natural frequencies and mode shapes. Time-history analyses, using site-specific acceleration records, were conducted for the seismically isolated bridge model and an identical, non-isolated bridge model.

For the bridge under consideration, seismic isolation was found to appreciably reduce forces that the bridge substructure and foundation must resist. Seismic design forces for pier columns were reduced between 43 percent and 86 percent. The results of this study clearly show that seismic isolation is an effective means of reducing earthquake forces on bridges.

**KTC-98-20**      *“Seismic Evaluation of the Ohio River Bridge on US 51 at Wickliffe, Kentucky,”*  
**SPR-96-173**    *Issam E. Harik, \$516,611 (Other reports include: KTC 99-17, KTC 99-16, KTC 98-1, and KTC 97-1), SAC - Donald Herd*

## **ABSTRACT**

This report presents the seismic evaluation of the Ohio River bridge on US 51 at Wickliffe, Kentucky. The main bridge is a five-span single-deck cantilever through-truss type. The approach bridge has 21 spans on the Kentucky side and six spans on the Illinois side. Although this bridge has not yet been subjected to a moderate or major earthquake, it is situated within the influence of the New Madrid seismic zone.

The seismic evaluation program consists of field testing and seismic response analysis. The modal properties of the main bridge are determined through field testing, and are used to calibrate the three dimensional finite element model. The finite element model is then subjected to time histories of the 50-year earthquake event. Stresses and displacement obtained are within the acceptable limits. Analytical results indicate that the main bridge will survive the projected 50-year earthquake without significant damage and no loss-of-span. Hence, it is not recommended to retrofit the main bridge.

The approach spans are analyzed using response spectrum method with simplified single-degree-of-freedom models. Most of the Kentucky and Illinois approach spans required additional anchor bolts at the bearings.

## ***TRAFFIC AND SAFETY***

***KTC-98-3      "1998 Highway Cost Allocation Update Technical Report," Samantha S. Jones,  
SPR-98-186    \$43,502, SAC - Glenn Mitchell***

### **ABSTRACT**

This update of the highway cost allocation study is the eighth in a recent series begun in the early 1980's by the Kentucky Transportation Cabinet and the Kentucky Transportation Center. The primary objectives were to determine the level of revenue contribution and cost responsibility for each class of highway user. The base year of the study is FY 97; the most recent time period for which revenue and cost data were available. Highway user or travel activity for calendar year 1996 was the most recent available. A basic premise of the study was that only state maintained highways were of interest in recouping the costs expended to construct and maintain the system. In 1996, this system comprised 27,350 miles of the 73,170 miles of roads and streets in Kentucky, while accommodating 84 percent of all travel.

There were 17 highway user classes with which revenue contribution and cost responsibility were associated. Primary sources of revenue included fuel taxes, registration fees, usage taxes, tolls, and other motor carrier and federal taxes and fees. Primary expenditure categories include construction (subdivided into six categories), maintenance and traffic, administration, and enforcement. Construction was subdivided into planning and design; right of way; utility relocation; grade, drain and surfacing; resurfacing; bridges; and miscellaneous.

Results from the analysis indicate that cost responsibility is borne most heavily by cars and motorcycles with 45.74 percent; followed by heavy trucks with gross weights of 60,000 pounds or more at 26.22 percent. Pickups and other vehicles registered in the 6,000 pound category were responsible for 20.72 percent of the cost. The ratio of percentage revenue attributed to percentage cost allocated was also determined in the study. A ratio of one indicates that the revenue and cost percentages are in balance for a particular vehicle type. Cars (0.94), buses (0.78) and heavy trucks (0.91) contribute less revenue than their cost responsibility dictates.

***KTC-98-5      "Investigation and Analysis of Heavy Truck Accidents," Jerry G. Pigman,  
SPR-98-181    \$122,316, SAC - William Madden***

### **ABSTRACT**

The objectives of this study were to investigate and analyze traffic accidents involving trucks and to study the relationship between heavy loads and truck braking efficiency. Field tests were made to determine the effect of increased loads on the ability of a truck to brake to a stop and determine if the trucks could meet the requirements of the Federal Motor Carrier Safety Regulations. The test combination truck with a gross weight of up to 151,180 was able to meet both braking distance and maximum G requirements. The test single-unit truck failed to meet requirements only at the maximum weight tested of 120,680 pounds.

Accident data were analyzed for the three-year period of 1994 through 1996. Characteristics of truck

accidents were compared to all accidents. A detailed analysis was conducted for all fatal accidents involving a truck. Average and critical numbers and rates of truck accidents were calculated and one-mile sections having a critical rate were located with an investigation conducted at a sample of these sections.

**KTC-98-9      “Intelligent Transportation Systems Strategic Plan,” Jerry G. Pigman,  
SPR-97-188    \$140,353, SAC -Nancy Albright**

## **ABSTRACT**

This report represents Phase One of the Strategic Plan for Intelligent Transportation Systems (ITS) in Kentucky. The purpose of this Strategic Plan is to offer a vision for ITS in Kentucky and to identify key goals for each functional area of ITS. A mission, vision, and goals are presented for Advanced Rural Transportation Systems, Advanced Traveler Information Systems, and Commercial Vehicle Operations. Phase 11 (final report) of the Strategic Plan will include a mission, vision, and goals for the remaining areas of ITS including Advanced Traffic Management Systems, Advanced Public Transportation Systems, and Advanced Vehicle Safety Systems. Also included in this report is an inventory of existing ITS projects in Kentucky. Some of the fundamental elements of achieving the ITS vision are presented and discussed, including public relations, marketing, and organizational structure.

This plan serves as the beginning of the foundation for development of a Statewide ITS Architecture and an ITS Business Plan.

**KTC-98-11      “Evaluation of Kentucky’s Driver License Point System and Retesting  
SPR-98-184    Criteria,” Kenneth R. Agent, \$149,082, SAC - Steve Coffey**

## **ABSTRACT**

The objectives of this study were to: a) summarize the characteristics of drivers in Kentucky involved in traffic crashes and b) evaluate and recommend improvements to Kentucky’s driver license point system. Comparisons of driving record were made by driver age and sex. The relationship between violations and traffic crashes was analyzed. The change in driving record after various interventions was investigated. Based on a review of the point systems used in other states and the analysis of the driver’s license file, a revised point system was recommended for use in Kentucky.

**KTC-98-14      “A Methodology for Evaluating Large Truck Access to Intermodal and Other  
SPR-98-189    Facilities,” Lisa Altman-Hall, \$187,706, SAC - Carl Dixon and Bruce Siria**

## **ABSTRACT**

Kentucky is a state that despite its relatively small area has an extensive multimodal freight transportation network. This paper presents the findings of the statewide freight commodity flow analysis that relate to one of the multimodal transportation planning issues currently facing Kentucky:

the relative role of various modes in freight transport and the potential for modal substitution. Issues affecting the type of data required for statewide freight planning studies are also discussed. Statewide issues, such as modal substitution questions, require freight commodity data by origin, destination and mode. The aggregation of data from the Bureau of Transportation Statistics or other publicly available data was considered unfeasible and the study team was referred to Reebie Associates for detailed freight commodity flow information. The Reebie freight commodity flow data were analyzed by mode, commodity and spatial zone within Kentucky to determine where the potential for modal substitution was greatest. Three areas of the state were found in which improvements for intermodal facilities for water and rail transportation might be considered. The data confirmed the extent of Kentucky's multimodal reliance, i.e. the majority of freight (by weight and volume) traveling to and from Kentucky moves by non-highway modes. However, it was also noted that rail and water connections between Kentucky and certain areas of the United States may need further consideration, as almost all freight to and from these areas move by truck. Several other projects within the state are ongoing with these data.

## ***TECHNOLOGY TRANSFER***

***KTC-98-19     "Annual Assessment of Customer Needs and Satisfaction," Patsy Anderson,  
SPR-98-175     \$46,815, SAC - Chuck Knowles***

### **ABSTRACT**

The purpose of this study was to continue the efforts begun in 1997 to monitor Kentucky public opinion regarding the quality of the highway system and also include a portion to measure satisfaction with the current drivers' license and registration renewal processes. Kentucky's 1998 public opinion is compared to data collected in 1997 to gauge Kentucky's progress over the past year, and is compared to the NQI Survey done on the national level to show how Kentuckian's opinions compare to those nationwide.

## ***1997***

## ***CONSTRUCTION MANAGEMENT***

***KTC-97-22     "Development of A Critical Path Method Specification and A Training Program  
SPR-96-167     for Use of CPM for KyTC," Donn E. Hancher, \$115,533, SAC - John Sacksteder***

### **ABSTRACT**

The Critical Path Method scheduling technique is outlined as it applies to KyTC projects. Special Provision 82 (94) and its requirements are outlined.

## **PAVEMENTS AND MATERIALS**

**KTC-97-5**      *“Performance and Cost Effectiveness of Pavement Edge Drains,” L. John  
SPR-92-143      Fleckenstein, \$309,967, SAC - Gary Sharpe*

### **ABSTRACT**

It is apparent from research conducted under this study that edge drains increase subgrade strength through the removal of water. It is also apparent in most cases that the edge drains increase pavement life by approximately seven years. Current cost benefit analysis indicates that edge drains can provide a cost savings of approximately \$200,000 dollars a mile over the life of the pavement. Research also indicates that if edge drains are not properly installed and maintained they can do more damage than good. It is evident that edge drains should be inspected with a pipeline camera prior to final acceptance and prior to rehabilitation.

**KTC-97-8**      *“Subsurface Drainage of Highway Pavements,” David Q. Hunsucker,  
SPR-92-142      \$278,103, SAC - Gary Sharpe*

### **ABSTRACT**

Properly designed and constructed drainage layers can be used for effective control of surface water infiltration. Former pavement design methods often have resulted in base courses that have not drained well, thereby resulting in some premature failures of the pavement structure. The Kentucky Department of Highways is currently reviewing proposed guidelines for design of highway pavements. The guidelines propose the use of open graded, free draining, aggregate bases for controlling infiltrated surface water. However, Interim design guidelines do not specifically address the design of aggregate drainage blankets. The purpose of this study was to develop recommendations relating to the specification, design, and construction of pavement drainage layers as an integral part of the pavement structure.

## **POLICY AND SYSTEMS ANALYSIS**

**KTC-97-14**      *“Legislation Review and Recommendations to Reduce Evasion of Kentucky Road  
SPR-93-153      Fund Revenues,” Dwight Denison, \$143,993, SAC - Glenn Mitchell*

### **ABSTRACT**

The Federal Highway Trust and the Kentucky Road Fund were established to provide earmarked resources for maintaining and building federal and state roadways. Two major sources of the revenues for the Kentucky Road Fund are the motor fuels tax and vehicle licensing and registration fees/taxes. Evasion of the road fund revenues reduces the fiscal resources available to build and maintain roads. This report reviews state statutes to identify the anti-evasion strategies that have been adopted in the southern region. Recommendations are provided to address evasion of the motor fuel tax, vehicle registration, and the ad valorem property tax.



## **STRUCTURES**

**KTC-97-1**      *“Dynamic Site Periods for Jackson Purchase Region of Western Kentucky,” R. Street, \$516,611, (Other reports include: KTC 99-17, KTC 99-16, KTC 98-20, and KTC 98-1), SAC - Donald Herd*

### **ABSTRACT**

Bridges, overpasses, and other engineered structures in the Jackson Purchase region of Western Kentucky are, of necessity, built on a thick column of loose to semi-consolidated sediments. Because these sediments tend to amplify seismically induced ground motions at preferred periods, structures with natural periods close to the preferred periods of amplification of the ground motions are particularly vulnerable to damages during an earthquake because of in-phase resonance.

For this report, conventional seismic refraction and reflection techniques were used to determine the shear-wave velocities of the more poorly consolidated, near-surface sediments for a matrix of sites in the region. Conventional seismic P-wave reflections along with existing drill hole and seismic reflection data in the region were then used to determine the depth to the top of the bedrock at the sites investigated. These data were used in SHAKE 91 to calculate the fundamental period of the ground motion at the sites. This period identified in the study as the dynamic site period, is the period at which ground motions in the sedimentary column are most apt to be amplified as a result of a seismic shear wave propagating from the top of the bedrock to the surface. Based on the results in this report, it is recommended that bridges, overpasses, and other engineered structures built in the region be designed so that their natural periods do not coincide with the fundamental period of the sedimentary column thereby avoiding damage during an earthquake as a result of in-phase resonance.

## **TRAFFIC AND SAFETY**

**KTC-97-6**      *“Evaluation of Speed Limits in Kentucky,” Jerry G. Pigman, \$116,946, SAC - SPR-96-172      Simon Cornett*

### **ABSTRACT**

The objective of this study were to examine current criteria and procedures used for setting speed limits on public roads and to recommend appropriate speed limits for various types of roadways. The major components of the study were a review of the literature, the collection and analysis of speed data, and the collection and analysis of accident data.

The speed data showed that operating speeds for most types of highways are substantially above the posted speed limit and that speeds of cars are slightly above those of trucks. Data taken before and after speed limit changes show that operating speeds are changed much less than the change in speed limit. Speed data taken in construction zones show that, while speeds are lower than typical for the specific type of highway, there is a disregard for lowered speed limits. A comparison of accident rates at adjacent sections of interstate showed no increase in either total, injury, or fatal injury rates at locations with a 65 mph speed limit compared to a 55 mph speed limit.

Except where legislatively mandated speed limits apply, the 85<sup>th</sup> percentile speed should be used to

establish speed limits. Maximum limits are given for various types of roadways. In many instances, the maximum speed limit is slightly higher than the existing limit. Also, different speed limits for cars and trucks are recommended for some roadways. An engineering study must be conducted before the speed limit should be increased for any specific section of roadway.

## **1996**

### **CONSTRUCTION MANAGEMENT**

**KTC-96-14**     *“Cost Estimating and Forecasting for Highway Work in Kentucky,” James D. Stevens, \$314,308, SAC - Charles Raymer*

#### **ABSTRACT**

There is a need for better cost estimating and forecasting for highway work in the Commonwealth of Kentucky. KRS45.245 grants the Interim Joint Committee on Transportation oversight of the biennial highway plan, including a review of all authorized highway project phases that exceed their estimates by 15 percent. In recent years, the Kentucky Transportation Cabinet has suffered the loss of many resources necessary to produce good cost estimates,

Estimates developed using current methods are not sufficiently accurate to preclude cost overruns in excess of 15 percent. Over the 1992 and 1994 bienniums, 362 overruns totaling \$162,487,511 have been submitted to the Committee. All have been approved for additional funding. KYEstimate, a cost-per-mile model, has been developed to improve estimates made in the district offices. This program uses preconstruction and construction data to calculate a unit cost for projects. New projects may then be estimated on past cost of similar projects.

### **ENVIRONMENTAL ANALYSIS**

**KTC-96-7**     *“Environmentally Safe Protective Coatings for Steel Structures - New Construction and Maintenance Painting,” Theodore Hopwood, II, \$258,987, SAC - Robert Bantz*

#### **ABSTRACT**

The purpose of this study was to: 1) assist KyTC in identifying protective coatings for structural steel that would meet current and pending environmental regulations, and 2) to evaluate overcoating procedures that would be cost-effective and provide regulatory (OSHA and EPA) compliance.

A coatings research program was conducted that included: 1) laboratory accelerated corrosion/weathering tests, 2) field exposure tests, and 3) experimental maintenance painting of entire bridges by overcoating. Each of those tasks was intended to address different issues. Regulations

concerning volatile organic compound limits for coating systems used in new construction were studied and recommendations provided to KyTC on new systems that would provide potential advantages in application and performance.

The laboratory testing was used to evaluate seven candidate overcoating systems and three new construction coatings system. Field exposure tests consisted of coatings patches applied to bridges and scrap steel. Those tests provided useful information concerning the durability of candidate maintenance coatings and the practicality of experimental application procedures. Eighteen complete bridge maintenance painting projects were conducted the KyTC experimental overcoating program that employed experimental specifications and coatings system. Those projects were inspected prior to, during and subsequent to completion. Long-term performance of most projects has been very good.

## **PAVEMENTS AND MATERIALS**

**KTC-96-8**      *“A Proposed Method of Calibration and Correlation of Weigh-in-Motion  
HPR-94-159 Systems,” David L. Allen, \$235,610, SAC - Rob Bostrom*

### **ABSTRACT**

There are various types of weigh-in-motion systems currently in use by agencies that collect weight data. These include load cells, ending plate, capacitance pads, piezoelectric cables, and bridge WIM's. The response and behavior of these systems differs from one type to another. Most states calibrate these systems by one of two methods. The first is to calibrate by running a truck or trucks of known weights across the scales a number of times. The second is to use a sample of trucks from the traffic stream.

This report details a field calibration and correlation test site between a slow-speed WIM at a permanent weigh station and five other WIM systems. These other systems were a capacitance pad, a piezoelectric cable installed in a rigid slab, a piezoelectric cable installed in a flexible pavement, a bridge WIM installed on a simple span, and a bridge WIM installed on a continuous span. From this test site, a method of calibrating WIM systems was developed that uses the accumulative distribution functions of the vehicle gross weights from the traffic stream.

By developing a distribution function for a standard scale (in this case, the permanent weigh station) and also for the WIM system being calibrated, a continuous calibration function can be developed between the two systems. Any weights obtained by the calibrated scale in the future can then be corrected to the standard scale by application of the continuous calibration function,

This report details a recommended calibration procedure for correlating all scales in the state by use of calibration distribution functions, a computer program (“WIMBOTH”) was developed to calculate the distribution functions and the calibration functions.

**KTC-96-10**     *“Evaluation of Superior Performing Portland Cement Concrete Pavements in  
HPR-94-156     Kentucky,” Jerry G. Rose, \$94,960, SAC - Gary Sharpe*

#### **ABSTRACT**

This research report describes a program of study directed at determining common factors which have contributed to the superior performances of selected sections of Portland cement concrete (PCC) pavements in Kentucky. The program involved an extensive survey of Kentucky’s interstate, parkway and other primary routes to determine locations of PCC pavement sections greater than 15 years old that have performed satisfactorily with minimal maintenance. Twelve of the best performing PCC pavements with long service life and heavy traffic were selected for detailed evaluations. Initial designs were documented and a series of in-situ pavement tests were conducted including core drilling and materials sampling. Laboratory tests were conducted on the pavement samples to ascertain basic physical properties.

#### **POLICY AND SYSTEMS ANALYSIS**

**KTC-96-16**     *“The Motor Fuel Tax Evasion Issue in Kentucky,” Dwight Denison , \$143,993,  
SPR-93-153     SAC - Glenn Mitchell*

#### **ABSTRACT**

Tax evasion is an elusive and burgeoning problem. Methods of tax evasion are continually changing and adapting to new methods of tax enforcement. However, there are strategies that can reduce the potential loss due to fuel tax evasion. This study of fuel tax evasion in Kentucky and the southeastern states provides additional information regarding the causes and nature of the road fund tax evasion problem, and identifies state and federal/state efforts to mitigate the tax evasion challenge. The concepts, issues, and recommendations in this report can aid in reducing evasion of the Kentucky motor fuels tax, thereby, enhancing the efficiency and equity in the administration of the motor fuels tax and increase the resources collected in the Kentucky Road Fund.

## **1995**

#### **PAVEMENTS AND MATERIALS**

**KTC-95-1**     *"A User's Guide for By-Product and Discarded Material Utilization in Highway  
HPR-93-152     Construction and Maintenance," Kamyar Mahboub, \$118,460, SAC - Willie  
McCann*

#### **ABSTRACT**

This report presents a user’s guide for an expert decision-making system that utilizes findings of an extensive literature search and review conducted as part of this study. The literature search and

review were conducted to determine current attitudes and document available technical data relative to the use of recyclable and recoverable materials in highway construction and maintenance activities. Specifically, the literature search focused upon the engineering, economic, and performance aspects of using recyclable and recoverable materials in highway construction and maintenance projects. The effort centered upon asphalt and Portland cement concrete pavement recycling, discarded tire recycling, reuse of paint removal wastes, fly ash, glass, alternative fuels, and other miscellaneous recycled and recovered materials as related to construction and maintenance of highways. Additionally, regulatory and policy matters associated with the use of recyclable and recoverable materials in the transportation area were investigated during the review of pertinent literature.

The user's guide was developed for use by Kentucky Transportation Cabinet officials to address a large number of multi-disciplinary issues. These issues may include, but not be limited to environmental impact, legal or legislative mandates, performance, cost and implementation. Since the aforementioned variables change with time, there is a user-friendly updating feature for the expert decision-making system. This feature of the expert system format presentation represents a major advantage over the familiar report format. An expert system has three major parts: a user interface, an inference engine, and stores expertise. When consulting the expert system, the user states a problem and interacts with the system. An expert system's inference engine is software that actually carries out the reasoning needed to solve a problem. This software draws upon the stored expertise in order to reach its conclusions.

**KTC-95-6      *“Development of An Alternate Methodology for Identifying Heavy/Coal Trucks***  
**HPR-94-159    *and Calculating ESAL's/Axle and Axles/Truck,” Jack A. Harison, \$286,686***  
***(Other report included: KTC 95-7), SAC - Rob Bostrom***

## **ABSTRACT**

The objective of this report was to modify current ESAL calculation procedures to provide more definitive and accurate methods for reflecting the effects of coal movement and a more flexible approach to accommodate evolving needs.

To accomplish this objective, all routes in Kentucky were classified by whether it carried coal or not. If the route carried coal, it was further classified by the amount of coal carried, by the functional class of the highway, and by the county in which it was located.

A computer program named “COALR” was developed to calculate ESALs per axle and axle per truck based on the amount of coal hauled on the route, its functional class, and the Annual Average Daily Traffic (AADT).

In addition, a method was developed for estimating the amount of coal hauled on a particular route when weight data was not available for that route. Tables are presented in the report that permits the user to estimate coal haulage by ton-miles.

The information in the report provides a means for estimating ESALs/axle and axles/truck for routes in Kentucky and allows the user to estimate ton-miles hauled on an individual route.

**KTC-95-13**     *“A Life-Cycle Cost Analysis Program for Kentucky Pavements,” Jack A. Harrison,*  
**SPR-87-118**     *\$313,006 (no records on \$ spent for 87-88 - only on next 5 years), SAC -*  
*Gary Sharpe*

#### **ABSTRACT**

This report documents the development of a life-cycle cost procedure and program for project-level pavements. Included in this report are the descriptions of the models that are included in the computer program. A traffic growth model is described along with performance models for asphaltic concrete pavements and Portland cement pavements. The program calculates when rehabilitation is predicted at all future dates during the design life or analysis period. Recommended overlay thicknesses are also given. Because maintenance costs for Kentucky are not available, maintenance is treated as an annual, per-square-yard quantity. User costs, in the form of a delay model are also presented. All future costs are calculated in terms of present worth.

A users manual is also included in the report. Appendix D is a listing of the source code for the computer program.

**KTC-95-18**     *“Pavement Distress at Intersections,” David Q. Hunsucker, \$145,704, SAC -*  
**HPR-92-144**     *Gary Sharpe*

#### **ABSTRACT**

Asphaltic concrete pavements at intersections and their approaches, where traffic is required to stop and start, exhibit several types of distress. Among the more prominent forms of these distresses are deep rutting, pushing and shoving, and severe washboarding. Prior research in this area has shown the leading causes of pavement failures at these locations are primarily materials related. Meaningful amounts of funds allocated for maintenance operations are exhausted each year to rehabilitate intersection pavements that have become safety hazards as a result of simple traffic action. Significant savings may be realized if intersections and their approaches are designed and constructed to accommodate the shear stresses as well as fatigue to which they are subjected. The overall purpose of this study has been to understand the factors that influence these distresses and determine procedures that may be implemented economically to significantly reduce the costly and repeated rehabilitation of intersection pavements. This report examines several innovative techniques used to accommodate higher stresses realized at these locations including whitetopping with Portland cement concrete, high-density plastic geogrids, and polymer-modified asphalts.

#### **POLICY AND SYSTEMS ANALYSIS**

**KTC-95-3**     *"Toward Determining/Optimal Transportation Department Resource*  
**HPR-94-165**     *Requirements: An Examination of State Privatization Trends Among Selected*  
*States," Dr. Merl Hackbart, \$106,859, SAC - Bill Seymour*

#### **ABSTRACT**

The purpose of this project was to conduct a preliminary analysis of employment and privatization trends in state transportation departments. This project involved a review of recent literature on public sector privatization efforts, an analysis of all state transportation departments in order to locate a sample of states with transportation system characteristics similar to those of Kentucky, and a survey of the sample states to determine privatization trends in the functional areas of administration, maintenance, design, engineering, enforcement and safety, and construction.

The study finds that among transportation departments in the 14 sample states, average annual increases in private sector service contracts and expenditures out-paces increase in state expenditures for transportation functional areas and FTE's tenfold. In addition, while significant privatization activities were found in each functional area, privatization activities were most evident in the functional areas of maintenance and design.

### **TRAFFIC AND SAFETY**

**KTC-95-5      “Development of A Safety Management System,” Kenneth R. Agent, \$146,651,  
HPR-93-149    SAC - Lonnie Yates/Steve Coffey**

#### **ABSTRACT**

The Safety Management System (SMS) is one of six management systems mandated by Section 1034 of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). The overall goal of a SMS is to reduce the number and severity of traffic crashes. It is to be comprehensive in that it incorporates all public roads and all contributing factors associated with the driver, the vehicle, and the roadway. The objective of this study was to develop a procedure to implement a SMS for Kentucky. A recommended process is described. Agencies and organizations were identified which have a role or interest in Traffic Safety. Contacts were made with these agencies and organizations, and their activities in the area of traffic safety were described. The purpose of these contacts was to establish a safety inventory for the state.

The composition of a Safety Management Steering Committee was recommended along with subcommittees in the general areas of roadway, human, and vehicle factors as well as information services and evaluation. Data needs to be used in the implementation of the SMS were identified. An evaluation process was described. A schedule for the implementation of the SMS was recommended.

**KTC-95-7      “Equivalent Single Axleload Computer Program Enhancements,” Jerry G.  
HPR-94-159    Pigman, \$286,686 (Other report included: KTC 95-6), SAC - Rob Bostrom**

#### **ABSTRACT**

The objectives of the study were to review and modify previously used Equivalent Single Axleload (ESAL) prediction procedures and to develop a more efficient procedure. As part of the effort to simplify the procedure, a subtask was undertaken to reduce a number of highway functional classes being used to process data for the ESAL estimation procedure. Another objective was to develop a more definitive and accurate method for reflecting the effects of coal or heavy truck movements. Results of this task

were documented as Research Report KTC-95-6.

Analyses were performed and validated to reduce the twelve functional classes to six aggregate categories. The overall ESAL estimating process, which was previously accomplished using mainframe computer programs, was converted to microcomputer/PC programs and documented in detail. A procedure for processing ESAL data by aggregate classes was documented and example output was presented. An analysis was performed to determine the reliability of traffic parameter estimates used in the ESAL estimating process. Results were produced to identify the number of volume, classification and weigh-in-motion stations required to adequately define the traffic characteristics of a specific functional or aggregate class.

**KTC-95-25     *“Impacts of Extended Weight Coal Haul Road System,” Jerry G. Pigman,***  
**HPR-83-151     *\$142,408, SAC - Charles Briggs***

## **ABSTRACT**

The Extended-Weight Coal Haul Road System, created by the Kentucky Legislature in 1986, consists of all roads which carry over 50,000 tons of coal in a calendar year. Trucks hauling coal on this system are authorized to exceed normal weight limits through the payment of an annual decal fee. A research study was initiated in July of 1992 to analyze the impacts of the extended-weight system.

Analyses in this report are based on the following: historical data on coal production and transportation; data from coal decal applications; interviews of legislators, transportation officials, coal company representatives, and coal trucking representatives; newspaper articles; vehicle classification data; analyses of pavement costs; pavement rideability data; and accident data.

Primary conclusions included: 1) The extended-weight system has apparently been somewhat successful in accomplishing the objective of enhancing the competitiveness and economic viability of the Kentucky coal industry; 2) Overall accident rates did not increase as a result of implementation of the extended-weight system, but the fatal accident injury rates were significantly higher on the extended-weight system and for trucks operating with the coal decal; 3) Advance-warning flashers have been evaluated and recommended as a means of reducing intersection accidents involving heavy/coal trucks; 4) The coal-decal fee structure results in a net annual loss in Road Fund revenue of approximately \$2 million; 5) Forty percent of revenue from decal fees are allocated to counties even though county-maintained roads comprise only eight percent of the extended-weight system; 6) Heavier weights of coal-decal trucks add approximately \$9 million annually to the pavement overlay costs; 7) Road users throughout the state are subsidizing the movement of Kentucky coal by participating in the cost of maintaining and improving the highway system; and 8) Possibly reflecting the increased funding of extended-weight roads, the rideability index has risen to a level above the statewide average.

The primary recommendation was that the extended-weight system should evolve into a comprehensive trucking network. A “Resource and Commodity Highway System” was evaluated as a separate study and found to be a feasible and desirable means of providing a trucking highway network that is fully compatible with the dimensions and characteristics of large trucks.





University of Kentucky  
College of Engineering

## KENTUCKY TRANSPORTATION CENTER

### ***Our Mission***

We provide services to the transportation community through research, technology transfer and education. We create and participate in partnerships to promote safe and effective transportation systems.

### ***We Value...***

Teamwork -- Listening and Communicating, Along with Courtesy and Respect for Others  
Honesty and Ethical Behavior  
Delivering the Highest Quality Products and Services  
Continuous Improvement in All That We Do

*For more information or a complete publication list, contact us at:*

Kentucky Transportation Center  
176 Raymond Building  
University of Kentucky  
Lexington, Kentucky 40506-0281

(859) 257-4513  
(859) 257-1815 (FAX)  
1-800-432-0719  
[www.engr.uky.edu/ktc](http://www.engr.uky.edu/ktc)  
[ktc@engr.uky.edu](mailto:ktc@engr.uky.edu)